

08-03-00

A

Practitioner's Docket No. 63937-104

PATENT

Preliminary Classification:

Proposed Class:

Subclass:

NOTE: "All applicants are requested to include a preliminary classification on newly filed patent applications. The preliminary classification, preferably class and subclass designations, should be identified in the upper right-hand corner of the letter of transmittal accompanying the application papers, for example "Proposed Class 2, subclass 129." M.P.E.P. § 601, 7th ed.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Box Patent Application
Assistant Commissioner for Patents
Washington, D.C. 20231

NEW APPLICATION TRANSMITTAL

Transmitted herewith for filing is the patent application of
Inventor(s): Tzyy-Shuh Chang

WARNING: 37 C.F.R. § 1.41(a)(1) points out:

"(a) A patent is applied for in the name or names of the actual inventor or inventors.

"(1) The inventorship of a nonprovisional application is that inventorship set forth in the oath or declaration as prescribed by § 1.63, except as provided for in § 1.53(d)(4) and § 1.63(d). If an oath or declaration as prescribed by § 1.63 is not filed during the pendency of a nonprovisional application, the inventorship is that inventorship set forth in the application papers filed pursuant to § 1.53(b), unless a petition under this paragraph accompanied by the fee set forth in § 1.170 is filed supplying or changing the name or names of the inventor or inventors."

For (title):

OPTICAL OBSERVATION DEVICE AND METHOD FOR OBSERVING
ARTICLES AT ELEVATED TEMPERATURES

CERTIFICATION UNDER 37 C.F.R. § 1.10*

(Express Mail label number is mandatory.)

(Express Mail certification is optional.)

I hereby certify that this New Application Transmittal and the documents referred to as attached therein are being deposited with the United States Postal Service on this date August 2, 2000, in an envelope as "Express Mail Post Office to Addressee," mailing Label Number EK393503690US, addressed to the: Assistant Commissioner for Patents, Washington, D.C. 20231.

Donna Crumit

(type or print name of person mailing paper)



Signature of person mailing paper

WARNING: Certificate of mailing (first class) or facsimile transmission procedures of 37 C.F.R. § 1.8 cannot be used to obtain a date of mailing or transmission for this correspondence.

*WARNING: Each paper or fee filed by "Express Mail" must have the number of the "Express Mail" mailing label placed thereon prior to mailing, 37 C.F.R. § 1.10(b).

"Since the filing of correspondence under § 1.10 without the Express Mail mailing label thereon is an oversight that can be avoided by the exercise of reasonable care, requests for waiver of this requirement will not be granted on petition." Notice of Oct. 24, 1996, 60 Fed. Reg. 56,439, at 56,442.

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08/02/00

Jc695 U.S. PTO

Jc695 U.S. PTO 09/630479

08/02/00

09/630479 08/02/00

1. Type of Application

This new application is for a(n)

(check one applicable item below)

- ☒ Original (nonprovisional)
☐ Design
☐ Plant

WARNING: Do not use this transmittal for a completion in the U.S. of an International Application under 35 U.S.C. § 371(c)(4), unless the International Application is being filed as a divisional, continuation or continuation-in-part application.

WARNING: Do not use this transmittal for the filing of a provisional application.

NOTE: If one of the following 3 items apply, then complete and attach **ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF A PRIOR U.S. APPLICATION CLAIMED** and a **NOTIFICATION IN PARENT APPLICATION OF THE FILING OF THIS CONTINUATION APPLICATION**.

- ☐ Divisional.
☐ Continuation.
☐ Continuation-in-part (C-I-P).

2. Benefit of Prior U.S. Application(s) (35 U.S.C. §§ 119(e), 120, or 121)

NOTE: A nonprovisional application may claim an invention disclosed in one or more prior filed copending nonprovisional applications or copending international applications designating the United States of America. In order for a nonprovisional application to claim the benefit of a prior filed copending nonprovisional application or copending international application designating the United States of America, each prior application must name as an inventor at least one inventor named in the later filed nonprovisional application and disclose the named inventor's invention claimed in at least one claim of the later filed nonprovisional application in the manner provided by the first paragraph of 35 U.S.C. § 112. Each prior application must also be:

- (i) An international application entitled to a filing date in accordance with PCT Article 11 and designating the United States of America; or
(ii) Complete as set forth in § 1.51(b); or
(iii) Entitled to a filing date as set forth in § 1.53(b) or § 1.53(d) and include the basic filing fee set forth in § 1.16; or
(iv) Entitled to a filing date as set forth in § 1.53(b) and have paid therein the processing and retention fee set forth in § 1.21(f) within the time period set forth in § 1.53(f).

37 C.F.R. § 1.78(a)(1).

NOTE: If the new application being transmitted is a divisional, continuation or a continuation-in-part of a parent case, or where the parent case is an International Application which designated the U.S., or benefit of a prior provisional application is claimed, then check the following item and complete and attach **ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED**.

WARNING: If an application claims the benefit of the filing date of an earlier filed application under 35 U.S.C. §§ 120, 121 or 365(c), the 20-year term of that application will be based upon the filing date of the earliest U.S. application that the application makes reference to under 35 U.S.C. §§ 120, 121 or 365(c). (35 U.S.C. § 154(a)(2) does not take into account, for the determination of the patent term, any application on which priority is claimed under 35 U.S.C. §§ 119, 365(a) or 365(b).) For a c-i-p application, applicant should review whether any claim in the patent that will issue is supported by an earlier application and, if not, the applicant should consider canceling the reference to the earlier filed application. The term of a patent is not based on a claim-by-claim approach. See Notice of April 14, 1995, 60 Fed. Reg. 20,195, at 20,205.

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WARNING: When the last day of pendency of a provisional application falls on a Saturday, Sunday, or Federal holiday within the District of Columbia, any nonprovisional application claiming benefit of the provisional application **must** be filed prior to the Saturday, Sunday, or Federal holiday within the District of Columbia. See 37 C.F.R. § 1.78(a)(2).

- ☒ The new application being transmitted claims the benefit of prior U.S. application(s). Enclosed are ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

3. Papers Enclosed

- A. Required for filing date under 37 C.F.R. § 1.53(b) (Regular) or 37 C.F.R. § 1.153 (Design) Application

14 Pages of specification

3 Pages of claims

5 Sheets of drawing

WARNING: **DO NOT** submit original drawings. A high quality copy of the drawings should be supplied when filing a patent application. The drawings that are submitted to the Office must be on strong, white, smooth, and non-shiny paper and meet the standards according to § 1.84. If corrections to the drawings are necessary, they should be made to the original drawing and a high-quality copy of the corrected original drawing then submitted to the Office. Only one copy is required or desired. For comments on proposed then-new 37 C.F.R. § 1.84, see Notice of March 9, 1988 (1990 O.G. 57-62).

NOTE: "Identifying indicia, if provided, should include the application number or the title of the invention, inventor's name, docket number (if any), and the name and telephone number of a person to call if the Office is unable to match the drawings to the proper application. This information should be placed on the back of each sheet of drawing a minimum distance of 1.5 cm. (5/8 inch) down from the top of the page . . ." 37 C.F.R. § 1.84(c).

(complete the following, if applicable)

- ☐ The enclosed drawing(s) are photograph(s), and there is also attached a "PETITION TO ACCEPT PHOTOGRAPH(S) AS DRAWING(S)." 37 C.F.R. § 1.84(b).
- ☐ formal
- ☒ informal

B. Other Papers Enclosed

2 Pages of declaration and power of attorney

1 Pages of abstract

 Other

4. Additional papers enclosed

- ☐ Amendment to claims
- ☐ Cancel in this applications claims _____ before calculating the filing fee. (At least one original independent claim must be retained for filing purposes.)
- ☐ Add the claims shown on the attached amendment. (Claims added have been numbered consecutively following the highest numbered original claims.)
- ☐ Preliminary Amendment
- ☐ Information Disclosure Statement (37 C.F.R. § 1.98)
- ☐ Form PTO-1449 (PTO/SB/08A and 08B)
- ☐ Citations

- ☐ Declaration of Biological Deposit
- ☐ Submission of "Sequence Listing," computer readable copy and/or amendment pertaining thereto for biotechnology invention containing nucleotide and/or amino acid sequence.
- ☐ Authorization of Attorney(s) to Accept and Follow Instructions from Representative
- ☐ Special Comments
- ☐ Other

5. Declaration or oath (including power of attorney)

NOTE: A newly executed declaration is not required in a continuation or divisional application provided that the prior nonprovisional application contained a declaration as required, the application being filed is by all or fewer than all the inventors named in the prior application, there is no new matter in the application being filed, and a copy of the executed declaration filed in the prior application (showing the signature or an indication thereon that it was signed) is submitted. The copy must be accompanied by a statement requesting deletion of the names of person(s) who are not inventors of the application being filed. If the declaration in the prior application was filed under § 1.47, then a copy of that declaration must be filed accompanied by a copy of the decision granting § 1.47 status or, if a nonsigning person under § 1.47 has subsequently joined in a prior application, then a copy of the subsequently executed declaration must be filed. See 37 C.F.R. §§ 1.63(d)(1)-(3).

NOTE: A declaration filed to complete an application must be executed, identify the specification to which it is directed, identify each inventor by full name including family name and at least one given name, without abbreviation together with any other given name or initial, and the residence, post office address and country or citizenship of each inventor, and state whether the inventor is a sole or joint inventor. 37 C.F.R. § 1.63(a)(1)-(4).

NOTE: "The inventorship of a nonprovisional application is that inventorship set forth in the oath or declaration as prescribed by § 1.62, except as provided for in § 1.53(d)(4) and § 1.63(d). If an oath or declaration as prescribed by § 1.63 is not filed during the pendency of a nonprovisional application, the inventorship is that inventorship set forth in the application papers filed pursuant to § 1.53(b), unless a petition under this paragraph accompanied by the fee set forth in § 1.17(f) is filed supplying or changing the name or names of the inventor or inventors." 37 C.F.R. § 1.41(a)(1).

- ☒ Enclosed

Executed by

(check all applicable boxes)

- ☒ inventor(s).

- ☐ legal representative of inventor(s).
37 C.F.R. §§ 1.42 or 1.43.

- ☐ joint inventor or person showing a proprietary interest on behalf of inventor who refused to sign or cannot be reached.

- ☐ This is the petition required by 37 C.F.R. § 1.47 and the statement required by 37 C.F.R. § 1.47 is also attached. See item 13 below for fee.

- ☐ Not Enclosed.

NOTE: Where the filing is a completion in the U.S. of an International Application or where the completion of the U.S. application contains subject matter in addition to the International Application, the application may be treated as a continuation or continuation-in-part, as the case may be, utilizing ADDED PAGE FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION CLAIMED.

- ☐ Application is made by a person authorized under 37 C.F.R. § 1.41(c) on behalf of all the above named inventor(s).

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(The declaration or oath, along with the surcharge required by 37 C.F.R. § 1.16(e) can be filed subsequently).

- ☐ Showing that the filing is authorized.
(not required unless called into question. 37 C.F.R. § 1.41(d))

6. Inventorship Statement

WARNING: If the named inventors are each not the inventors of all the claims an explanation, including the ownership of the various claims at the time the last claimed invention was made, should be submitted.

The inventorship for all the claims in this application are:

- ☒ The same.

or

- ☐ Not the same. An explanation, including the ownership of the various claims at the time the last claimed invention was made,
☐ is submitted.
☐ will be submitted.

7. Language

NOTE: An application including a signed oath or declaration may be filed in a language other than English. An English translation of the non-English language application and the processing fee of \$130.00 required by 37 C.F.R. § 1.17(k) is required to be filed with the application, or within such time as may be set by the Office. 37 C.F.R. § 1.52(d).

- ☒ English
☐ Non-English
☐ The attached translation includes a statement that the translation is accurate. 37 C.F.R. § 1.52(d).

8. Assignment

- ☒ An assignment of the invention to OG Technology, Inc.
☐ is attached. A separate ☐ "COVER SHEET FOR ASSIGNMENT (DOCUMENT) ACCOMPANYING NEW PATENT APPLICATION" or ☐ FORM PTO 1595 is also attached.
☒ will follow.

NOTE: "If an assignment is submitted with a new application, send two separate letters—one for the application and one for the assignment." Notice of May 4, 1990 (1114 O.G. 77-78).

WARNING: A newly executed "CERTIFICATE UNDER 37 C.F.R. § 3.73(b)" must be filed when a continuation-in-part application is filed by an assignee. Notice of April 30, 1993, 1150 O.G. 62-64.

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9. Certified copy

Certified copy(ies) of application(s)

Country	Appln. No.	Filed
Country	Appln. No.	Filed
Country	Appln. No.	Filed

from which priority is claimed

- ☐ is (are) attached.
☐ will follow.

NOTE: The foreign application forming the basis for the claim for priority must be referred to in the oath or declaration. 37 C.F.R. § 1.55(a) and 1.63.

NOTE: This item is for any foreign priority for which the application being filed directly relates. If any parent U.S. application or International Application from which this application claims benefit under 35 U.S.C. § 120 is itself entitled to priority from a prior foreign application, then complete item 18 on the ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

10. Fee Calculation (37 C.F.R. § 1.16)

- A. ☒ Regular application

CLAIMS AS FILED			
Number filed	Number Extra	Rate	Basic Fee 37 C.F.R. § 1.16(a) \$690.00
Total			
Claims (37 C.F.R. § 1.16(c))	- 20 =	×	\$ 18.00
Independent			
Claims (37 C.F.R. § 1.16(b))	- 3 =	×	\$ 78.00
Multiple dependent claim(s), if any (37 C.F.R. § 1.16(d))			
		+	\$260.00

- ☐ Amendment cancelling extra claims is enclosed.
☐ Amendment deleting multiple-dependencies is enclosed.
☐ Fee for extra claims is not being paid at this time.

NOTE: If the fees for extra claims are not paid on filing they must be paid or the claims cancelled by amendment, prior to the expiration of the time period set for response by the Patent and Trademark Office in any notice of fee deficiency. 37 C.F.R. § 1.16(c).

Filing Fee Calculation \$ 690.00

- B. ☐ Design application
(\$310.00—37 C.F.R. § 1.16(f))

Filing Fee Calculation \$

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- C. ☐ Plant application
(\$480.00—37 C.F.R. § 1.16(g))

Filing fee calculation

\$ _____

11. Small Entity Statement(s)

- ☐ Statement(s) that this is a filing by a small entity under 37 C.F.R. § 1.9 and 1.27 is (are) attached.

WARNING: "Status as a small entity must be specifically established in each application or patent in which the status is available and desired. Status as a small entity in one application or patent does not affect any other application or patent, including applications or patents which are directly or indirectly dependent upon the application or patent in which the status has been established. The refiling of an application under § 1.53 as a continuation, division, or continuation-in-part (including a continued prosecution application under § 1.53(d)), or the filing of a reissue application requires a new determination as to continued entitlement to small entity status for the continuing or reissue application. A nonprovisional application claiming benefit under 35 U.S.C. § 119(e), 120, 121, or 365(c) of a prior application, or a reissue application may rely on a statement filed in the prior application or in the patent if the nonprovisional application or the reissue application includes a reference to the statement in the prior application or in the patent or includes a copy of the statement in the prior application or in the patent and status as a small entity is still proper and desired. The payment of the small entity basic statutory filing fee will be treated as such a reference for purposes of this section." 37 C.F.R. § 1.28(a)(2).

WARNING: "Small entity status must not be established when the person or persons signing the . . . statement can unequivocally make the required self-certification." M.P.E.P., § 509.03, 6th ed., rev. 2, July 1996 (emphasis added).

(complete the following, if applicable)

- ☐ Status as a small entity was claimed in prior application

_____ / _____, filed on _____, from which benefit is being claimed for this application under:

- 35 U.S.C. § ☐ 119(e),
☐ 120,
☐ 121,
☐ 365(c),

and which status as a small entity is still proper and desired.

- ☐ A copy of the statement in the prior application is included.

Filing Fee Calculation (50% of A, B or C above)

\$ _____

NOTE: Any excess of the full fee paid will be refunded if small entity status is established and a refund request are filed within 2 months of the date of timely payment of a full fee. The two-month period is not extendable under § 1.136. 37 C.F.R. § 1.28(a).

12. Request for International-Type Search (37 C.F.R. § 1.104(d))

(complete, if applicable)

- ☐ Please prepare an international-type search report for this application at the time when national examination on the merits takes place.

13. Fee Payment Being Made at This Time

☐ Not Enclosed

☐ No filing fee is to be paid at this time.

(This and the surcharge required by 37 C.F.R. § 1.16(e) can be paid subsequently.)

☒ Enclosed

☒ Filing fee \$ 690.00

☐ Recording assignment
(\$40.00; 37 C.F.R. § 1.21(h))
(See attached "COVER SHEET FOR
ASSIGNMENT ACCOMPANYING NEW
APPLICATION".) \$ _____

☐ Petition fee for filing by other than all the
inventors or person on behalf of the inventor
where inventor refused to sign or cannot be
reached
(\$130.00; 37 C.F.R. §§ 1.47 and 1.17(i)) \$ _____

☐ For processing an application with a
specification in
a non-English language
(\$130.00; 37 C.F.R. §§ 1.52(d) and 1.17(k)) \$ _____

☐ Processing and retention fee
(\$130.00; 37 C.F.R. §§ 1.53(d) and 1.21(f)) \$ _____

☐ Fee for international-type search report
(\$40.00; 37 C.F.R. § 1.21(e)) \$ _____

NOTE: 37 C.F.R. § 1.21(f) establishes a fee for processing and retaining any application that is abandoned for failing to complete the application pursuant to 37 C.F.R. § 1.53(f) and this, as well as the changes to 37 C.F.R. §§ 1.53 and 1.78(a)(1), indicate that in order to obtain the benefit of a prior U.S. application, either the basic filing fee must be paid, or the processing and retention fee of § 1.21(f) must be paid, within 1 year from notification under § 53(f).

Total fees enclosed \$ 690.00

14. Method of Payment of Fees

☐ Check in the amount of \$ _____

☒ Charge Account No. 04-2223 in the amount of
\$ 690.00

A duplicate of this transmittal is attached.

NOTE: Fees should be itemized in such a manner that it is clear for which purpose the fees are paid. 37 C.F.R. § 1.22(b).

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15. Authorization to Charge Additional Fees

WARNING: If no fees are to be paid on filing, the following items should not be completed.

WARNING: Accurately count claims, especially multiple dependent claims, to avoid unexpected high charges, if extra claim charges are authorized.

- ☒ The Commissioner is hereby authorized to charge the following additional fees by this paper and during the entire pendency of this application to Account No.

04 2223 :

- ☒ 37 C.F.R. § 1.16(a), (f) or (g) (filing fees)
☒ 37 C.F.R. § 1.16(b), (c) and (d) (presentation of extra claims)

NOTE: Because additional fees for excess or multiple dependent claims not paid on filing or on later presentation must only be paid or these claims cancelled by amendment prior to the expiration of the time period set for response by the PTO in any notice of fee deficiency (37 C.F.R. § 1.16(d)), it might be best not to authorize the PTO to charge additional claim fees, except possibly when dealing with amendments after final action.

- ☒ 37 C.F.R. § 1.16(e) (surcharge for filing the basic filing fee and/or declaration on a date later than the filing date of the application)
☒ 37 C.F.R. § 1.17(a)(1)-(5) (extension fees pursuant to § 1.136(a)).
☒ 37 C.F.R. § 1.17 (application processing fees)

NOTE: "... A written request may be submitted in an application that is an authorization to treat any concurrent or future reply, requiring a petition for an extension of time under this paragraph for its timely submission, as incorporating a petition for extension of time for the appropriate length of time. An authorization to charge all required fees, fees under § 1.17, or all required extension of time fees will be treated as a constructive petition for an extension of time in any concurrent or future reply requiring a petition for an extension of time under this paragraph for its timely submission. Submission of the fee set forth in § 1.17(a) will also be treated as a constructive petition for an extension of time in any concurrent reply requiring a petition for an extension of time under this paragraph for its timely submission." 37 C.F.R. § 1.136(a)(3).

- ☐ 37 C.F.R. § 1.18 (issue fee at or before mailing of Notice of Allowance, pursuant to 37 C.F.R. § 1.311(b))

NOTE: Where an authorization to charge the issue fee to a deposit account has been filed before the mailing of a Notice of Allowance, the issue fee will be automatically charged to the deposit account at the time of mailing the notice of allowance. 37 C.F.R. § 1.311(b).

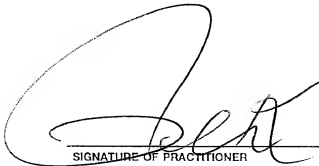
NOTE: 37 C.F.R. § 1.28(b) requires "Notification of any change in status resulting in loss of entitlement to small entity status must be filed in the application . . . prior to paying, or at the time of paying, . . . the issue fee. . . ." From the wording of 37 C.F.R. § 1.28(b), (a) notification of change of status must be made even if the fee is paid as "other than a small entity" and (b) no notification is required if the change is to another small entity.

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16. Instructions as to Overpayment

NOTE: "... Amounts of twenty-five dollars or less will not be returned unless specifically requested within a reasonable time, nor will the payer be notified of such amounts; amounts over twenty-five dollars may be returned by check or, if requested, by credit to a deposit account." 37 C.F.R. § 1.26(a).

- ☒ Credit Account No. 04-2223
☐ Refund


SIGNATURE OF PRACTITIONER

Reg. No. 31,843

Tel. No. (248) 203-0

Robert L. Kelly
(type or print name of attorney)
Dykema Gossett PLLC
39577 Woodward Avenue, Suite 300
P.O. Address

Customer No.

Bloomfield Hills MI 48304

(New Application Transmittal [4-1]—page 10 of 11)

☒ **Incorporation by reference of added pages**

(check the following item if the application in this transmittal claims the benefit of prior U.S. application(s) (including an international application entering the U.S. stage as a continuation, divisional or C-I-P application) and complete and attach the ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED)

- ☒ Plus Added Pages for New Application Transmittal Where Benefit of Prior U.S. Application(s) Claimed

Number of pages added 5

- ☐ Plus Added Pages for Papers Referred to in Item 4 Above

Number of pages added _____

- ☐ Plus added pages deleting names of inventor(s) named in prior application(s) who is/are no longer inventor(s) of the subject matter claimed in this application.

Number of pages added _____

- ☐ Plus "Assignment Cover Letter Accompanying New Application"

Number of pages added _____

☐ **Statement Where No Further Pages Added**

(if no further pages form a part of this Transmittal, then end this Transmittal with this page and check the following item)

- ☐ This transmittal ends with this page.

Practitioner's Docket No. 63,937-104**PATENT****ADDED PAGES FOR APPLICATION TRANSMITTAL WHERE BENEFIT OF
PRIOR U.S. APPLICATION(S) CLAIMED**

NOTE: See 37 C.F.R. § 1.78.

17. Relate Back

WARNING: If an application claims the benefit of the filing date of an earlier filed application under 35 U.S.C. §§ 120, 121 or 365(c), the 20-year term of that application will be based upon the filing date of the earliest U.S. application that the application makes reference to under 35 U.S.C. §§ 120, 121 or 365(c). (35 U.S.C. § 154(a)(2) does not take into account, for the determination of the patent term, any application on which priority is claimed under 35 U.S.C. §§ 119, 365(a) or 365(b).) For a c-i-p application, applicant should review whether any claim in the patent that will issue is supported by an earlier application and, if not, the applicant should consider canceling the reference to the earlier filed application. The term of a patent is not based on a claim-by-claim approach. See Notice of April 14, 1995, 60 Fed. Reg. 20,195, at 20,205.

(complete the following, if applicable)

- ☒ Amend the specification by inserting, before the first line, the following sentence:

A. 35 U.S.C. § 119(e)

NOTE: "Any nonprovisional application claiming the benefit of one or more prior filed copending provisional applications must contain or be amended to contain in the first sentence of the specification following the title a reference to each such prior provisional application, identifying it as a provisional application, and including the provisional application number (consisting of series code and serial number)." 37 C.F.R. § 1.78(a)(4).

- ☒ "This application claims the benefit of U.S. Provisional Application(s) No(s).:

APPLICATION NO(S):**FILING DATE**

60 / 151,565

 _____ / _____
 _____ / _____

08/31/99 "
 _____ "
 _____ "

10857 U.S. PTO
 09/630479
 08/02/00

B. 35 U.S.C. §§ 120, 121 and 365(c)

NOTE: "Except for a continued prosecution application filed under § 1.53(d), any nonprovisional application claiming the benefit of one or more prior filed copending nonprovisional applications or international applications designating the United States of America must contain or be amended to contain in the first sentence of the specification following the title a reference to each such prior application, identifying it by application number (consisting of the series code and serial number) or international application number and international filing date and indicating the relationship of the applications. . . . Cross-references to other related applications may be made when appropriate." (See § 1.14(a)). 37 C.F.R. § 1.78(a)(2).

- ☐ "This application is a
☐ continuation
☐ continuation-in-part
☐ divisional

of copending application(s)

- ☐ application number 0 / _____ filed on _____"
☐ International Application _____ filed on _____
_____ and which designated the U.S."

NOTE: The proper reference to a prior filed PCT application that entered the U.S. national phase is the U.S. serial number and the filing date of the PCT application that designated the U.S.

NOTE: (1) Where the application being transmitted adds subject matter to the International Application, then the filing can be as a continuation-in-part or (2) if it is desired to do so for other reasons then the filing can be as a continuation.

NOTE: The deadline for entering the national phase in the U.S. for an international application was clarified in the Notice of April 28, 1987 (1079 O.G. 32 to 46) as follows:

"The Patent and Trademark Office considers the International application to be pending until the 22nd month from the priority date if the United States has been designated and no Demand for International Preliminary Examination has been filed prior to the expiration of the 19th month from the priority date and until the 32nd month from the priority date if a Demand for International Preliminary Examination which elected the United States of America has been filed prior to the expiration of the 19th month from the priority date, provided that a copy of the international application has been communicated to the Patent and Trademark Office within the 20 or 30 month period respectively. If a copy of the international application has not been communicated to the Patent and Trademark Office within the 20 or 30 month period respectively, the international application becomes abandoned as to the United States 20 or 30 months from the priority date respectively. These periods have been placed in the rules as paragraph (h) of § 1.494 and paragraph (i) of § 1.495. A continuing application under 35 U.S.C. 365(c) and 120 may be filed anytime during the pendency of the international application."

- ☐ "The nonprovisional application designated above, namely application _____ / _____, filed _____, claims the benefit of U.S. Provisional Application(s) No(s).:

APPLICATION NO(S).:

FILING DATE

- ☐ Where more than one reference is made above, please combine all references into one sentence.

(Added Pages for Application Transmittal Where Benefit of Prior U.S. Application(s) Claimed
[4-1.1]—page 2 of 5)

18. Relate Back—35 U.S.C. § 119 Priority Claim for Prior Application

The prior U.S. application(s), including any prior International Application designating the U.S., identified above in item 17B, in turn itself claim(s) foreign priority(ies) as follows:

Country	Appln. no.	Filed on
The certified copy(ies) has (have)		
<input type="checkbox"/>	been filed on _____, in prior application 0 / _____, which was filed on _____	
<input type="checkbox"/>	is (are) attached.	

WARNING: The certified copy of the priority application that may have been communicated to the PTO by the International Bureau may **not** be relied on without any need to file a certified copy of the priority application in the continuing application. This is so because the certified copy of the priority application communicated by the International Bureau is placed in a folder and is not assigned a U.S. serial number unless the national stage is entered. Such folders are disposed of if the national stage is not entered. Therefore, such certified copies may not be available if needed later in the prosecution of a continuing application. An alternative would be to physically remove the priority documents from the folders and transfer them to the continuing application. The resources required to request transfer, retrieve the folders, make suitable record notations, transfer the certified copies, enter and make a record of such copies in the Continuing Application are substantial. Accordingly, the priority documents in folders of International applications that have not entered the national stage may not be relied on. Notice of April 28, 1987 (1079 O.G. 32 to 46).

19. Maintenance of Copendency of Prior Application

NOTE: The PTO finds it useful if a copy of the petition filed in the prior application extending the term for response is filed with the papers constituting the filing of the continuation application. Notice of November 5, 1985 (1060 O.G. 27).

- A.** ☐ Extension of time in prior application

(This item **must** be completed and the papers filed in the prior application, if the period set in the prior application has run.)

- ☐ A petition, fee and response extends the term in the pending prior application until _____
- ☐ A copy of the petition filed in prior application is attached.

- B.** ☐ Conditional Petition for Extension of Time in Prior Application

(complete this item, if previous item not applicable)

- ☐ A conditional petition for extension of time is being filed in the pending prior application.
- ☐ A copy of the conditional petition filed in the prior application is attached.

20. Further Inventorship Statement Where Benefit of Prior Application(s) Claimed

(complete applicable item (a), (b) and/or (c) below)

- (a) ☒ This application discloses and claims only subject matter disclosed in the prior application whose particulars are set out above and the inventor(s) in this application are

☒ the same.

- ☐ less than those named in the prior application. It is requested that the following inventor(s) identified for the prior application be deleted:

(type name(s) of inventor(s) to be deleted)

- (b) ☐ This application discloses and claims additional disclosure by amendment and a new declaration or oath is being filed. With respect to the prior application, the inventor(s) in this application are

☐ the same.

- ☐ the following additional inventor(s) have been added:

(type name(s) of inventor(s) to be added)

- (c) The inventorship for all the claims in this application are

☐ the same.

- ☐ not the same. An explanation, including the ownership of the various claims at the time the last claimed invention was made

☐ is submitted.

☐ will be submitted.

(Added Pages for Application Transmittal Where Benefit of Prior U.S. Application(s) Claimed
[4-1.1]—page 4 of 5)

21. Abandonment of Prior Application (if applicable)

- ☐ Please abandon the prior application at a time while the prior application is pending, or when the petition for extension of time or to revive in that application is granted, and when this application is granted a filing date, so as to make this application copending with said prior application.

NOTE: According to the Notice of May 13, 1983 (103, TMOG 6-7), the filing of a continuation or continuation-in-part application is a proper response with respect to a petition for extension of time or a petition to revive and should include the express abandonment of the prior application conditioned upon the granting of the petition and the granting of a filing date to the continuing application.

22. Petition for Suspension of Prosecution for the Time Necessary to File an Amendment

WARNING: "The claims of a new application may be finally rejected in the first Office action in those situations where (A) the new application is a continuing application of, or a substitute for, an earlier application, and (B) all the claims of the new application (1) are drawn to the same invention claimed in the earlier application, and (2) would have been properly finally rejected on the grounds of art of record in the next Office action if they had been entered in the earlier application." M.P.E.P., § 706.07(b), 7th ed.

NOTE: Where it is possible that the claims on file will give rise to a first action final for this continuation application and for some reason an amendment cannot be filed promptly (e.g., experimental data is being gathered) it may be desirable to file a petition for suspension of prosecution for the time necessary.

(check the next item, if applicable)

- ☐ There is provided herewith a Petition To Suspend Prosecution for the Time Necessary to File An Amendment (New Application Filed Concurrently)

23. Small Entity (37 C.F.R. § 1.28(a))

- ☐ Applicant has established small entity status by the filing of a statement in parent application /_____ on _____.
- ☐ A copy of the statement previously filed is included.

WARNING: See 37 C.F.R. § 1.28(a).

WARNING: "Small entity status must not be established when the person or persons signing the . . . statement can unequivocally make the required self-certification." M.P.E.P., § 509.03, 7th ed. (emphasis added).

24. NOTIFICATION IN PARENT APPLICATION OF THIS FILING

- ☐ A notification of the filing of this (check one of the following)
- ☐ continuation
 - ☐ continuation-in-part
 - ☐ divisional

is being filed in the parent application, from which this application claims priority under 35 U.S.C. § 120.

(Added Pages for Application Transmittal Where Benefit of Prior U.S. Application(s) Claimed
[4-1.1]—page 5 of 5)

OPTICAL OBSERVATION DEVICE AND METHOD FOR OBSERVING ARTICLES AT ELEVATED TEMPERATURES

This application claims the benefit of U.S. Provisional Application Serial No.
60/151,565 filed August 31, 1999.

Field of the Invention

The present invention relates generally to methods and devices for optically observing objects at high temperatures, including objects having significant self-emitted radiation.

Background of the Invention

In a number of industries, workers still visually inspect hot, glowing objects with their unprotected eyes. Direct exposure to infrared (IR) radiation, however, could cause physical injury to the workers. Accordingly, in some instances, light shields are worn which attenuate the radiation, thus providing some protection against IR exposure. However, the use of light shields often restricts the workers' mobility. For example, wearing a light shield may restrict their ability to physically interact with other objects that are not glowing, such as tools, controls and the like.

Conventional optical inspection devices have also been used to make observations/inspections of hot objects. For example, the so-called "passive method" utilizes a signal collector, either with CRT tubes, charge-coupled device (CCD) cameras, or IR cameras, to receive the self-emitted radiation from the hot objects. This approach is similar to the use of human vision, with the signal collectors essentially functioning as "eyes". The passive method, however, is subject to a phenomenon known as the "Cavity Radiator Effect." The Cavity Radiator Effect, postulated by Plank in 1900 and proved by

Einstein in the early 20th century, can deceive visual observers as to the true nature of the object observed. More specifically, based on this principle, concave surface features of a self-radiating object appear to be nearly perfect black bodies; accordingly, they may be mistaken as convex features. Additionally, the "illumination" is self-emitted and thus often carries unwanted information. Images collected via this passive method are generally not suitable for automatic machine vision applications.

Another prior art approach, the so-called "active method" utilizes external lights that are projected onto the hot object. A camera is used to collect the reflected, as well as the self-emitted radiation from the hot surfaces. In the active method the idea is to overpower the self-emitted radiation with very strong external radiation. In other words, the reflected light is within the spectrum of the predominant self-emitted radiation, but is distinguishable based on its intensity. The external lights can be designed to highlight the surface information of interest such as contour and surface dimples. The external radiation can be provided by various light-generating devices such as high power lamps or lasers.

Several problems, however, are associated with the active approach. First, few light sources exist that can overpower the radiation emitted by an object at 1350°C. Second, the self-emitted radiation still represents a problem: it degrades the signal quality of the reflected radiation. The signal-to-noise ratio (external light/self-emitted light) is typically low unless a very powerful light source is used. Third, these external light sources may be undesirable in the work environment because they are so intense.

Lasers have also been used as a light source to overpower self-emitted radiation from hot objects. Lasers can deliver extremely high power densities to reduce the significance of the self-emitted radiation. For example, a copper-based laser (radiating at 550 nm) has been used to overpower the self-emitted radiation of laser welding pool (temperature at about 3000°C), which typically radiates from 230 nm to long IR.

Another prior art approach uses YAG lasers (1060 nm) in arc welding (temperature at about 2500°C), which typically radiates a spectrum of from 275 nm to long IR. However, the use of lasers poses substantial problems. While lasers deliver high power density, the areas illuminated by the laser beams are small. Consequently, raster scanning

is typically required when lasers are used as illumination sources. Moreover, these high power lasers are expensive, bulky, and pose various risks. And, in order to operate a laser-based system, the users must be protected with light shields and other protective equipment.

5 The use of infrared (IR) sensors or cameras in a passive method vision system are also of limited value due to several factors. First, IR sensors/cameras provide significantly less pixel resolution than their CCD counterparts. Second, IR radiation cannot be focused as well as visible light due to its wavelength. Third, using IR sensors/cameras does not solve the problems associated with illumination or the Cavity Radiator Effect previously described.

10 There have been attempts to use a combination of passive and active methods, but this approach does not resolve the issues posed by the Cavity Radiator Effect and self-emitted radiation.

15 In the past, the difference between IR and visible light has been the focal point of solving the problems associated with the glare of hot objects. This approach is ill-conceived because a hot object can radiate with both IR and visible light radiation. For instance, steel radiates at 650 nm at 1200°C; that is, steel can radiate in RED as well as IR.

20 In addition, if the self-emitted radiation is not removed from the collected signal, the noise caused by the self-emitted radiation impairs the system's ability to gather detailed and accurate information about the hot object. The prior art lacks an effective means of removing the self-emitted radiation from the collected signal of a hot object. Finally, it is also believed that none of the devices enabled by the prior art is portable. This fact has limited the utility of such devices for certain applications. A portable device would be desirable for users who need to look at hot objects, but who do not need to take
25 quantitative measurements. The external light sources used in prior art devices are too powerful and/or heavy to be low-risk and portable. In summary, the prior art approaches have been of limited value. The present invention overcomes these problems.

Summary of the Invention

10 In one aspect, the present invention provides an optical system for characterizing
the surface of a high-temperature object. The optical system has an illumination source
5 which projects electromagnetic radiation toward the high-temperature object (applied
EMR). The applied electromagnetic radiation strikes the high-temperature object and is
reflected toward an EMR detector along with the self-emitted electromagnetic radiation and
any ambient (background) electromagnetic radiation. At least one component of the
reflected, applied EMR (which interacts with the surface of the high-temperature object) is
selectively detected by the EMR detector. In one aspect, this selectively identifiable,
reflected EMR comprises EMR having a wavelength which is determined on the basis of
the temperature of the object; that is, based on wavelength it is distinguishable from the
predominant self-emitted EMR and background EMR. In this manner, detection of the
reflected EMR provides an image of the high-temperature object which simulates the object
surface at low temperatures (i.e. below that producing any significant self-emitted EMR).

15 In another aspect, the component of the reflected, applied EMR which is identified
by the detector has a distinctive signature produced by modulating the applied EMR. In
this aspect, the optical system of the present invention further includes an EMR modulator.

20 In still another aspect, the present invention is implemented in a hand-held device.

Brief Description of the Drawings

Figure 1 is a diagram illustrating the present invention.

25 Figure 2 is a graph illustrating the wavelengths used in the present invention to
distinguish over the self-emitted radiation.

Figure 3 is a diagram illustrating one possible arrangement of a camera and
interference filter.

Figure 4 is another diagram illustrating one possible arrangement of a camera and
interference filter.

Figure 5 is another diagram illustrating one possible arrangement of a camera and interference filter.

Figure 6 is a graph illustrating the selection of a desired wavelength.

Figure 7 is a graph illustrating the use of a cut-off filter in the present invention.

Figure 8 is a graph illustrating the use of FM power modulation in the present invention.

Figure 9 is a graph illustrating the use of FM mechanical modulation in the present invention.

Figure 10 is a drawing of a hand-held device in accordance with the present invention.

Figure 11 is a schematic diagram of a two-camera embodiment of the present invention.

Description of the Preferred Embodiments

Referring now to Figure 1 of the drawings, in one embodiment of the present invention target or object 20 is seen having self-emitted electromagnetic radiation 22. Object 20 will typically comprise a part, for example a carbon steel part, a titanium alloy part, a glass part, or a ceramic part. It will be appreciated that in a number of part fabrication processes, these parts are heated to temperatures in excess of 900° C. It will also be understood that at these high temperatures, these parts emit a substantial amount of radiation which obscures view of the heated part (i.e., a dominant, self-emitted EMR spectrum).

Referring still to Figure 1 of the drawings, light source 24 is shown which projects electromagnetic radiation 26 toward the surface of part 20. Radiation 26 is the applied illumination. A component of applied illumination 26 is reflected by part 20 and is therefore illustrated in Figure 1 as reflected illumination 28. It will be noted that in tandem with reflected illumination 28, a portion of self-emitted radiation 22 (shown as 22') and some ambient radiation (not shown) takes the same path as reflected illumination 28.

Reflected illumination 28 (and self-emitted radiation 22') strike detector or sensor 30. As will be explained more fully herein, by distinguishing reflected illumination 28 from self-emitted radiation 22' (and any other "noise" such as ambient radiation) detector 30 can view object 20 as if the part were cool (essentially no self-emitted radiation).

In this embodiment of the invention, the wavelength of reflected radiation 28 is chosen such that it is distinguishable by detector 30 from the wavelength of the predominant self-emitted radiation 22'. More specifically, and referring now to Figure 2 of the drawings, the present invention provides an envelope of distinguishable applied illumination wavelengths as a function of the temperature of object 20. Accordingly, detector 30 senses or detects reflected illumination 28 which will have a wavelength under the curve. The preferred longest wavelength of reflected illumination 28 distinguishable from the self-emitted radiation (based on temperature) is set forth in Table 1 below:

Temperature (°C)	Longest Usable Wavelength (nm) for detection by sensor 30
< 800	700 nm
800	680
1000	645
1200	596
1400	545
1600	596
1800	441
2000	385
2200	338
2400	283
2600	233
3000	220
4000	185

The wavelengths above are derived based on the assumption that object 20 is a blackbody radiator and will be suitable for all applications because the spectral radiation intensity emitted by a real surface at a given temperature of a specific wavelength is always less than that emitted by a black body at the same temperature and wavelength. In one embodiment of the present invention, the process for selecting the applicable illumination wavelength λ_2 (arrow 26) can be determined more precisely as follows (Ozisik (1985), *Heat Transfer - A Basic Approach*, McGraw-Hill):

1. Define the highest object Temperature T.
2. Define the object emissivity $\epsilon(T, \text{material})$ which is a function of object temperature and material.
3. Obtain the self-emitted radiation spectrum based on the black body radiation function:

$$(1) \quad I(\lambda, T) = \frac{2\pi c^2 h}{\lambda^5} \cdot \frac{1}{e^{\frac{hc}{\lambda kT}} - 1}$$

and the material emissivity $\epsilon(T)$ where:

π	=	pi
C	=	light speed
h	=	Planck's constant
λ	=	wavelength
k	=	Boltzmann constant
ϵ	=	emissivity function of temperature, empirically obtained.

Together we have the radiation spectrum as:

$$(2) \quad R(\lambda, T, \text{material}) = \epsilon(T, \text{material}) \cdot I(\lambda, T)$$

If the material is known, Equation (2) can be reduced to

$$(3) \quad R(\lambda, T) = \epsilon(T) \cdot I(\lambda, T)$$

$R(\lambda, T)$ can be plotted in general as the solid lines in Figure 6. To further simplify, $\epsilon(T)$ can typically be assumed to be a constant.

4. With $R(\lambda, T)$, we can find a cut-off wavelength $\lambda_{\text{cut-off}}$ such that $R(\lambda_{\text{cut-off}}, T)$ is very small compared to the signal intensity of the external illuminating light $\eta(\lambda_{\text{ill}})$. Note that λ_{ill} is typically a shorter wavelength than $\lambda_{\text{cut-off}}$.

$$(4) \quad \gamma = \frac{\eta(\lambda_{\text{ill}})}{R(\lambda_{\text{cut-off}}, T)} \geq \gamma_0$$

where:

- $\eta(\lambda)$ = the intensity of the external illuminating light @ wavelength λ .
- λ_{ill} = the wavelength used for external illumination.
- γ = signal to noise ratio between the external illuminating light intensity and the self-emitted light intensity.
- γ_0 = specified signal to noise ratio limit that will satisfy the application.

$\eta(\lambda)$ is usually a function of the external illumination device. For instance, as stated above, a halite lamp has an $\eta(\lambda)$ like that seen in Figure 6.

Accordingly, the longest acceptable wavelength for the projected (reflected) EMR is that at which a blackbody radiates a spectral radiance of $5 \times 10^{-4} \text{ W/cm}^2 \cdot \text{nm}$ (i.e., power (in watts) per unit area per unit wavelength), at the highest temperature of the hot object at observation. Thus, I in equation (1) above becomes $5 \times 10^{-4} \text{ W/cm}^2$. By solving for λ and where T equals the object's highest temperature at observation, the longest permissible wavelength for a given object which can be distinguished from the self-emitted radiation can be determined.

Of course, the selection of λ_{ill} has to satisfy the sensitivity spectrum of detecting sensor 30. For instance, a CCD is sensitive to the range seen in Figure 6. λ_{ill} should be a wavelength which sensor 30 can detect. The λ_2 in Figure 6 is suitable for applications that are as hot as 1500°C .

Illumination source 24 may take a number of forms, but it must be capable of generating illumination which includes the required detectable wavelength. In other

words, if a wavelength of 645 nm or less is required to distinguish reflected radiation 28 from self-emitted radiation 22', then illumination source 24 must include EMR at 645 nm or less. One acceptable illumination source 24 is a halite lamp which emits EMR principally at 435 nm, 550 nm and 575 nm. Other preferred "light" sources for illumination source 24 are fluorescent lamps and xenon lamps.

In the case of a laser illuminator, due to the coherent nature of the laser illumination, the wavelength of the laser should be set to the required wavelength in accordance with Table I above.

A laser can also be used herein as a point illumination source. Detector 30 can be used to detect information at the point illuminated by the laser. When coupled with a direction set, such as a mirror set, lasers can be used to create a raster-scanned image. Lasers in the present invention, through the use of certain optics such as a beam expander, can also be used as a zone illumination source, where the zones are relatively small.

Lasers can also be used with certain optics for structured illumination (circular lines, straight lines, single lines or multiple lines etc.). The structured illumination can be used to extract the profiles of hot objects in accordance with the present invention. Multiple lasers can be used for multiple points, lines, or zones.

Of course, the intensity of the EMR projected from illumination source 24 (and the distances between source 24, target 22 and detector 30) must be such that sufficient signal strength is present at detector 30.

Those skilled in the art will appreciate that this invention can be used in conjunction with other illumination methods, such as front lighting, bright field or dark field, and back lighting (transmissive lighting). The illumination can be collimated or scattered, monochromatic or color, structured or non-structured. Multiple illumination schemes can be applied.

It is also possible to have multiple wavelengths of reflected illumination 28 detected by detector 30 in a system, as long as all of the selected wavelengths meet the criteria.

Those skilled in the art will also understand that additional optics, such as, but not limited to, lenses, mirrors, optical fibers, diffusers, collimators, condensers, prisms,

borescopes, endoscopes, and light guides, can be used in conjunction with the embodied designs. These optics can be used along with the illumination device (illuminating radiation source and modulator) to deliver the illumination onto the targeted hot object(s) for the purpose of illuminating multiple spots, or illuminating multiple objects, or any other intended illumination designs. These optics can also be used along with the signal collectors to receive the radiation signals from the hot object(s) for the purpose of meeting space constraints or to change the observation angles, for example.

Turning now to detector 30, a preferred detector is a CCD (charge coupled device) sensor. A CCD sensor is typically sensitive to wavelengths from 360 nm to 1000 nm. Some newer imaging sensors, such as blue enhanced CCD chips are sensitive to wavelengths from 175 nm to 1000 nm.

Of course, detector 30 must be able to detect the desired reflected illumination 28 wavelength. Preferably, an interference filter 32 blocks substantially all of the self-emitted EMR (and reflected EMR which is not at the desired imaging wavelength).

Interference filter 32 may be placed in front of the detector lens 34 as best shown in Figure 3, or between lens 34 and imaging sensor 36 as shown in Figure 4. It may also comprise multiple interference filters 38 in front of imaging sensor pixels 40 as shown in Figure 5. Those skilled in the art can further perceive that the arrangement in Figure 5 can be altered to facilitate the use of multiple illumination wavelengths. In this case, different interference filters 38, some working at one wavelength and some working at another, will be placed in front of pixels 40. With this arrangement, different pixels will be sensitive to the signals carried by different wavelengths. It is possible to have an aggregate of pixels, such as 2x3 or 3x1, within which each pixel is equipped with a different interference filter. This distribution is similar to that of a color CCD chip. It is also possible to have one type of interference filter installed in one zone of the imaging sensor while another type is installed in another zone.

It is also possible to facilitate the use of multiple wavelengths with multiple imaging sensors in a camera, with different interference filters in front of different imaging sensors. A prism is used to deliver optical radiations to all the imaging sensors. This arrangement

is similar to that of a 3-chip CCD color camera.

Those skilled in the art can also perceive the use of cut-off filters, instead of interference filters, in the application. The cut-off wavelength of the cut-off filter's transmittance curve must be at the desired wavelength. Figure 7 illustrates the concept.

5 With this setup, a single desired wavelength or multiple wavelengths can be used. In the case of multiple wavelengths, the signals carried by all the selected wavelengths will be treated as a combined signal.

Distortions in hot object imaging come from several sources. The above-described approach resolves the distortion influences of IR glare and Cavity Radiators. Another task is to creatively resolve the distortion associated with "mirage," the optical shimmering effect caused by localized air density non-uniformity. This is a common experience when one drives on a hot summer day. The road surface can appear to be "floating" and "wiggling." This "mirage" effect impairs the access to accurate measurements on hot objects through imaging.

10 In the present invention, controlled airflow 43 around hot object 20 decreases the temperature gradient around the hot object to remove air density distortion. Air flow 43 will be at a pre-selected temperature such that the temperature distribution of the hot object is not influenced adversely by such airflow. The speed of the airflow should be faster than about 0.01m/s in order to avoid localized air density non-uniformity.

15 In another embodiment of the invention, and referring again to Figure 1 of the drawings, signal modulator 42 is provided in order to place an identifiable "imprint" on applied illumination 26. In other words, in this embodiment of the invention the EMR from source 24 has an identifiable signature (other than merely wavelength) which allows reflected EMR 28 to be distinguished from self-emitted EMR 22'.

20 A schematic of this implementation is also shown in Figure 8. In this design, the power to illuminating source 24 is modulated through FM device 44. This FM signature will reside in the illuminating radiation 46 generated by source 24. The radiation is then projected onto the surface of hot object 20. The reflected signal 48 is received by imaging device 30 and then demodulated by FM demodulator 50 (through signal processing), based

on the preset FM frequency, to remove the non-modulated radiation 52, i.e., the self-emitted radiation. The demodulation signal processing can be performed in hardware or software or by a combination of both. The frequency modulation can be a sequence of frequencies such that the applied (projected) radiation is the nature of repeating square waves or can be dynamic modulation, producing a sine wave of changing frequencies which can be detected and demodulated as a reflected radiation.

Modulation can also be implemented mechanically, with a mechanical gate to "pulse" the illuminating radiation, as illustrated in Figure 9, or as a sine wave of intensity charges.

Devices which implement the embodied designs can be mobile, in part or as a whole. In one case the signal collector is mobile while the illumination device and hot object remain fixed. In another case the signal collector and the illumination device are both mobile and the hot object is stationary. It is also possible to move the hot object while the signal collector and the illumination device are stationary or mobile. It is also possible that two signal collectors or two illumination devices are used in one application, within which one is mobile and the other is stationary.

In still another embodiment, the present invention is implemented in the form of hand-held device 58. Referring now to Figure 10 of the drawings, hand-held camcorder 60 is shown having projection light 62 and interference filter 64. Camcorder 60, which may be digital or analog, is used as the signal collector. Interference filter 64 (preferably at 435 nm) is placed in front of the lens. External projection light 62 provides the applied illumination and radiates with a significant intensity (at 435 nm in this example). Light 62 could be fixed to the surface of camcorder 60 or be separate to provide multiple illumination angles. Camcorder 60 could use a magnetic tape, RAM, or any other suitable data storage device, or the device could be used simply as a display monitor. The video signal can be exported to a TV, a monitor, or a PC. Hand-held device 58 could be battery operated or could operate through an AC power supply. This device can be used to observe the hot processes or objects in accordance with the present invention, i.e. by projecting the desired illumination at a hot object and viewing the image (with the self-

emitted radiation filtered out) with the camcorder.

In another implementation, multiple signal collectors, such as cameras, can be used in one system to provide multiple viewpoints of the hot object. The use of multiple cameras can facilitate stereo imaging, which provides a three-dimensional image of the hot object. Also, multiple cameras can be used for multiple wavelengths, with each camera demodulating the signal carried by one wavelength.

In another embodiment and referring now to Figure 11, the invention can be used to protect individuals who must interact with hot objects. More specifically, in this design, two cameras 70,72 are used to capture the same field of view, with one capturing a normal image 74, which can be color or black/white, and the other capturing an image based on this invention 76 using beam splitter 77 and interference filter 79. In the normal image 74, hot object 78 is glowing. Glowing object 78 can be identified through a device, such as but not limited to, portable signal processor 82. With hot object 78 identified, the normal images of the glowing object can be replaced by room-temperature-appearance counterparts (cut out from 76 and pasted into 74). The synthesized image will be displayed to those who need to see everything in the field of view. Display 80 can be a monitor, a TV, or any other displaying device, including a displaying goggle. In order to identify the hot objects in the synthesized image, an indicator, such as, but not limited to, a red flashing boundary can be applied to the hot objects.

Example

An example of the present invention in one embodiment is as follows:

1. The external illumination source is a halite lamp. The halite radiation consists of three principal wavelengths, 435 nm, 550 nm, and 575 nm. The radiation at 435 nm is the most useful wavelength in this design because it is the farthest one away from the self-emitted radiation of a hot object. The hot object must be at a temperature of 1800° C or hotter for its self-emitted radiation to cover 435 nm, assuming the hot object is close to a black body.

2. The external radiation is projected onto the hot object and interacts with the surface of the hot object. The reflected radiation from the metal halite lamp (with

all three distinct wavelengths), the self-emitted radiation from the hot object, and any other radiation present are all blended together.

3. The blended radiation is then passed through an interference filter, which has a working wavelength at 435 nm. That is, only the radiation at 435 nm wavelength can pas through this interference filter. All other radiation will be blocked. This interference filter can be placed in front of the lens, or in front of the imaging sensor.

4. Only radiation with the pre-selected wavelength, in this case 435 nm, can reach the imaging sensor.

5. The hot object will appear to the image sensor, say a CCD chip, as though it were at room temperature.

6. The demodulated 435 nm signal is then translated into an electronic signal.

7. The electronic signal may be processed by a CPU, stored to a media, displayed on a monitor for observation by a human or any other form of processing.

Claims

I claim:

1. An optical system for producing an image of the surface of an object, said object having a characteristic, temperature-dependent, dominant, self-emitted EMR spectrum, comprising:

an EMR source for projecting electromagnetic radiation toward said object;

an EMR detector for selectively detecting a spectrum component of said projected EMR, said component being reflected by the surface of said object and being directed toward said EMR detector;

wherein said reflected component of said projected EMR has a wavelength different than said self-emitted, dominant EMR spectrum such that the reflected component can be distinguished from said self-emitted EMR based on wavelength.

2. An optical system as recited in claim 1, wherein the optical system includes a video recorder.

3. An optical system as recited in claim 1, wherein the EMR detector is a charge coupled device.

4. An optical system as recited in claim 1, wherein the EMR source is selected from the group consisting of metal-halide lamps, florescent lamps, and xenon lamps.

5. An optical system as recited in claim 1, wherein the EMR source is a laser.

6. An optical system as recited in claim 5, wherein said laser projects a zone illumination.

8. An optical system as recited in claim 5, wherein said laser projects structured illumination.

9. An optical system as recited in claim 1, wherein said detector detects multiple wavelengths of reflected EMR.

10. An optical system as recited in claim 3, wherein said charge coupled device is sensitive to wavelengths from 175 to 1000 nm.

11. An optical system as recited in claim 1, wherein said optical system further includes an interference filter in association with said EMR detector.

12. An optical system as recited in claim 11, wherein said interference filter blocks substantially all of said self-emitted EMR.

13. An optical system as recited in claim 1, wherein said optical system further includes a cut-off filter in association with said EMR detector.

14. An optical system as recited in claim 1, wherein said optical system further includes an airflow controller to provide air to said object to remove air density distortion.

15. An optical system as recited in claim 1, further including a frequency modulator in association with said EMR source for modulating the frequency of said projected EMR and further including a demodulator in association with said EMR detector.

17. An optical system as recited in claim 1, wherein said EMR source is a plurality of EMR sources.

18. An optical system as recited in claim 1, wherein said EMR detector is a plurality of EMR detectors.

19. An optical system for producing an image of the surface of a hot object, said object having a characteristic, dominant, self-emitted EMR spectrum, comprising:

- a video camera;
- an interference filter in association with said video camera for blocking substantially all of said self-emitted EMR spectrum; and
- a light source attached to said video camera.

Abstract

An optical system for viewing hot objects is disclosed. The system projects electromagnetic radiation to the part surface and detects the reflected portion. Based on wavelength and/or modulation of the applied illumination, the surface characteristics of the part can be observed without interference from self-emitted radiation.

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FIG 1

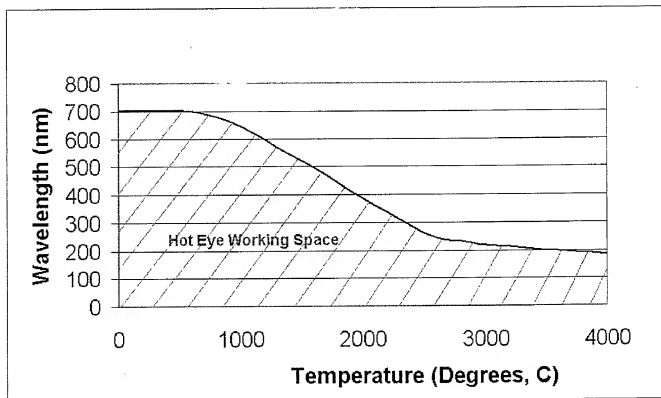
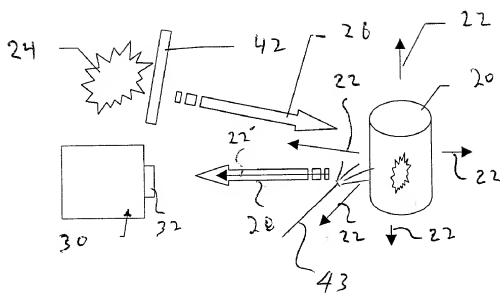
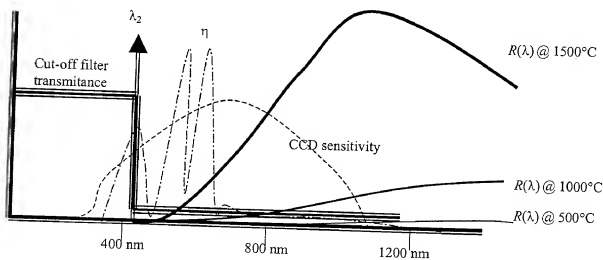
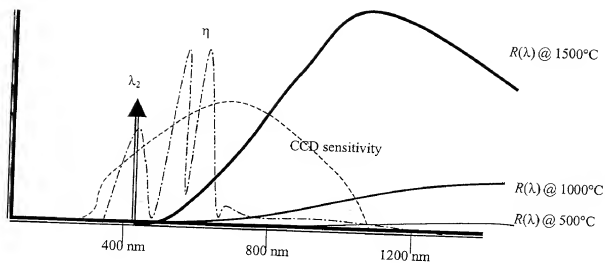


FIG 2

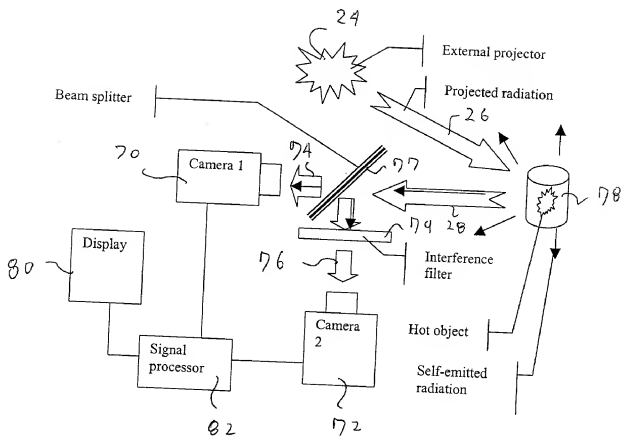
FIG 6



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FIG 7

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: Chang

Serial No. Unassigned

Filed: _____ Herewith _____

For: OPTICAL OBSERVATION DEVICE AND METHOD FOR OBSERVING ARTICLES AT ELEVATED TEMPERATURES

Attorney Docket No. 63,937-104

Assistant Commissioner For Patents
Washington, D.C. 20231

COMBINED DECLARATION AND POWER OF ATTORNEY
(Priority Claimed)

As the below-named inventor, I hereby declare: that my residence, post office address and citizenship are as stated near my name below; that I believe I am the original, first inventor of the subject matter which is described and claimed in the above-captioned United States patent application; that I have reviewed and understand the contents of the specification of the application, including the claims, as amended by any amendment filed herewith; that this application in part discloses and claims subject matter disclosed in prior provisional application Serial No. 60/151,565 filed 08/31/99, that I do not know and do not believe the same was ever known or used in the United States of America before my invention thereof, or patented or described in any printed publication in any country before my invention thereof for more than one year prior to this application, or in public use or on sale in the United States of America more than one year prior to this application; that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by my or my legal representatives or assigns more than twelve (12) months prior to this application; that I acknowledge my duty to disclose information of which I am aware that is material to the examination of this application in accordance with Title 37, Code of Federal Regulations Section 1.56(a); and that no application for patent or inventor's certificate on this invention has been filed in any country foreign to the United States of America prior to this application by me or my legal representatives or assigns except as follows: NONE

I hereby appoint Charles R. Rutherford, Registration No. 18,933; Robert L. Kelly, Registration No. 31,843; Kevin M. Hinman, Registration No. 35,193; Ernest E. Helms, Registration No. 29,721, William F. Kolakowski, Registration 41,908; and John F. Buckert, Registration No. 44,572, as my attorneys to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith. Please address all correspondence and telephone calls to:

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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